11 October 1979

MEMORANDUM FOR THE RECORD

SUBJECT: EASCON '79 Advanced Imagery Processing Techniques Session

STATI

1. On 10 October 1979 [redacted] attended the EASCON '79 session on Advanced Image Processing Techniques. The three-hour session contained four papers spanning examples of commercial practice, laboratory efforts, mathematical image models, and logical structures for picture interpretation.

2. The session chairman, Dr. Bob Hunt of University of Arizona, summarized the state of the art being both mature and embryonic. The mature aspects include the techniques employed in signal processing, the digital technology that enables handling large volumes of information, and the existing repertoire of "solved" problems. These "solved" problems include image compression, restoration/deblurring, and enhancement techniques described in "Digital Image Enhancement", a text by Andrews and Hunt.

3. Dr. Harry Andrews of COMTAL Corporation described his company's current (unclassified) system product, the Vision One/20. He spoke of real time digital image exploitation from filmless sensors having a synamic range greater than that of film. Sensors include FLIR, visible, radar, and sonar. The Landsat multispectral output (example of volume) was 2000x3000 pixels x 4 bands x 8 bits for 192 megabits per frame. Digital hardware technology now readily supports 10, 40, or 340 Megabyte per second processing that COMTAL uses (the first two are for 512 x 512 and 1024 x 1024 pixel systems). Cathode ray tube (CRT) technology is what appears to be the limiting factor for image size and resolution; that technology is driven by the purely commercial market. The Vision One/20 is a four-user (-port) system using pipeline processors to support a gross 134 M bit per 1/30 second refresh rate with a maximum of 512 bits/pixel. The processes supported include brightness/contrast transforms, spatial convolutions (e.g. edge enhancement, noise reduction), pixel-by-pixel multiply, divide, add, subtract, and finally, some feature classification processes. Fourier transforms are handled non-real time. He showed examples of extended operations using these elemental processes, including histogram equalization to allow color contrast stretching within color bands. He showed the difference between false color and pseudo color, the first being arbitrary translation of invisible to visible spectral components, the second the substitution of a selected gray level with a color to enhance subtle (otherwise invisible) changes in brightness. Some of the examples he used are included in the attached COMTAL brochure.

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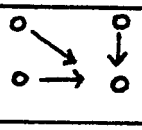
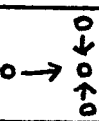
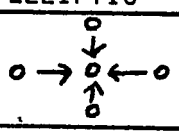
4. Mr. George Luhks (sp?) of the US Army Engineer Topographic Laboratories (Ft. Belvoir VA) spoke about his laboratory's involvement with hybrid digital/optical image processing systems. He described a Recording Optical Spectral Analyzer (ROSA) which, essentially, does a sampled optical Fourier Transform of a 0.5mm-10mm sigment of the photograph in the optical chain. The interface at the end of the optical chain to the digital is the optical sensor which, in one half of the plane provides 32 radial bands and, in the other half plane provides 32 angular wedge samples. The system produces very good identification of cloud covered areas and is being delivered, in packaged form, to Defense Mapping Agency in December, 1979. He also briefly described the UNIMACE stereo correlator and the Heterodyne Optical Correlator that does area correlation. He then flashed up a slide of the Hybrid Optical Digital Processor, that embodies many of the previous concepts, plus an element that provides (using PROM technology) a spatial filtering.

5. Dr. Anil K. Jain of the Department of Electrical Engineering at University of California, Davis, spoke on the utility of mathematical models in image processing. His division of the field of statistical image models is:

* covariance models,
* partial differential/difference equation models,
* minimum variance stochastic models,
* series expansion models, and
* other.

His presentation of covariance models showed "separable" models depending on the two orthogonal coordinates, independently, and an "isotropic" model that depends on interpixel distance. Covariance models can be used for all the usual image operations but lead to large covariance matrices (e.g. 256 x 256 pixels gives 65536 x 65536 covariance matrix), recursive algorithms, problems with covariance estimation and curve fitting. Also, non-stationary cases are non-tractable. He really likes partial difference equation models that have some structure that correlates to other fields (with obscure benefits). The three types of PDEs discussed are summarized in this table:

TYPE:	HYPERBOLIC	PARABOLIC	ELLIPTIC
PIXEL RELATION:			
CLASS:	CAUSAL	SEMI-CAUSAL	NON-CAUSAL
ALGORITHMS:	PREDICTIVE PART RECURSIVE	RECURSIVE-CAUSAL TRANSFORM-NON-CAUSAL	TRANSFORM

He used the parabolic p.d.e. for data compression, achieving an 8:1 reduction for an RPV-borne TV sensor subsystem for a Navy Ocean Systems Center application.

6. The final presentation was a flamboyant, philosophical discourse by Dr. Isreal Rosenfeld of the University of Maryland. He presented his/his group's view of the image processing paradigm. He extended a philosophy of "relaxation" as a way of dealing with two phases of the processing paradigm. "Relaxation" supports/implements an iterative, probabilistic classification. His view of the image processing paradigm decomposes into segmentation (parts), description (shape and texture), representation (relational structure-- a graph), and model matching (recognition). The old-style "compute a feature vector, map into feature spare, read label on segment of space" pattern recognition method maps into this paradigm neatly and is a degenerate case because segmentation is one point and representation is a one node graph. The problem areas in the four quadrants of his paradigm, he identified as these:

* Segmentation
  - Fast or Smart.*
  - Science or Art
* Representation
  - Coping with information loss.
* Model Matching
  - Coping with combinatorics.*

The two asterisked items above were identified candidates for the application of "relaxation". He referred to his paper in the May 1979 Procedings of the IEEE pleading for image models to support the "science" of segmentation. He referred to "pyramids" as a method to trace information that can be otherwise lost in the representation quadrant.

7. Relaxation, Rosenfeld described, is done in the following four steps:

* Estimate initial "probalitity" of each class for each object (e.g. pixel, node) based on intrinsic properties.

* Estimate pairwise compatibilities of each (object, class) pair with respect to neighbors (like a vertical edge implies increased probablility of vertical edge above and below and decreased probalility of vertical edge left and right)

* Use these compatibilities to compute increments/decrements to each (object, class) probability.

* Combine in(de)crements corresponding with each pair into a single consensus.

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He said the advantages were:

* Real parallel processing can be applied,
* committment deferred through use of iterative application of probabilistic/fuzzy criteria, and
* the use of context for convergent evidence.

The applications he referred to are the usual:

Segmentation
* thresholding
* spectral classification
* edge/curve detection
* shape discription in terms of ambiguous parts

Matching
* finding patterns of landmarks
* dealing with relational structures

He closed with: "We really don't know how to do anything yet but we know a hell of a lot more than we did twenty years ago".

[redacted]

25X

Attachment

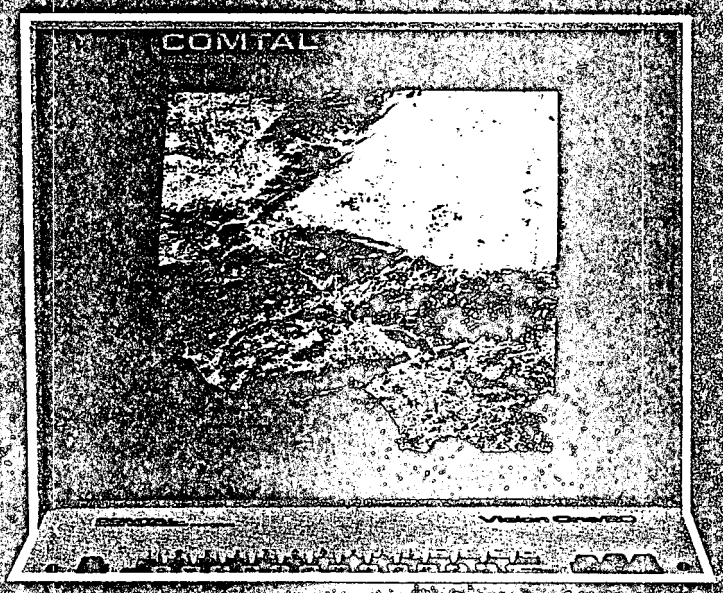
Distribution:

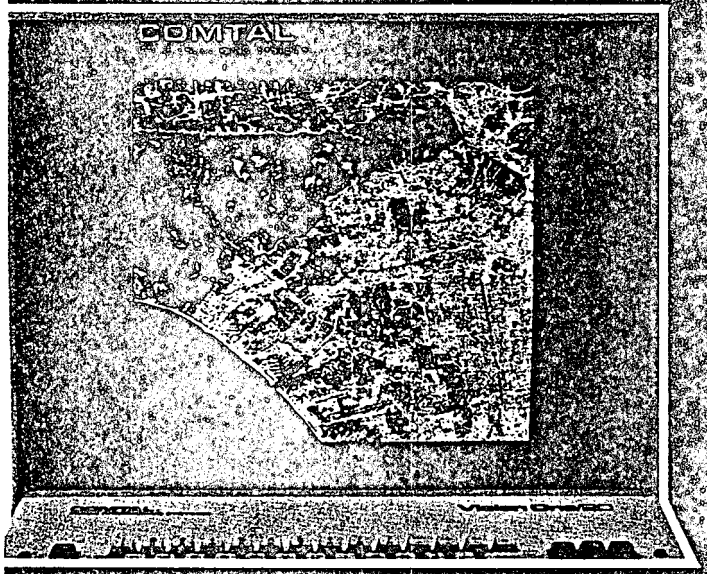
25X1A [redacted]

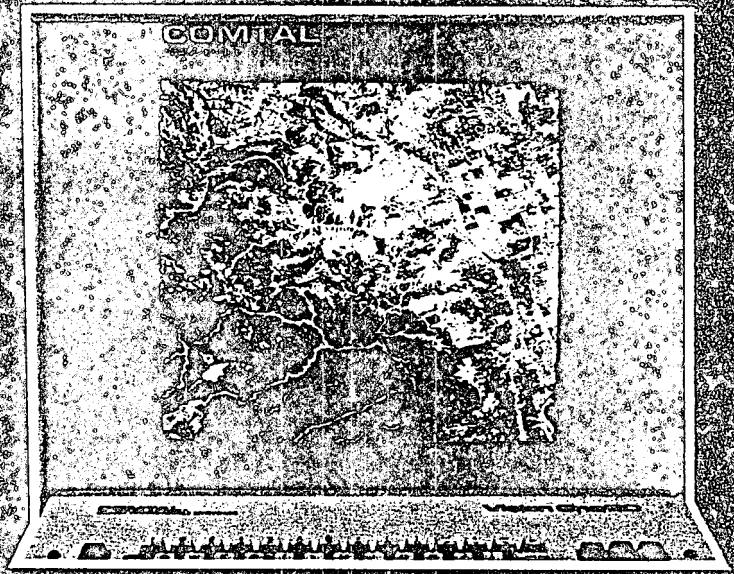
1 - DASITT File
3 - Working copies

Vision One/20

Vision One/20 offers the [illegible] art of digital image [illegible] interactive modular [illegible] high-end multi-purpose [illegible] and large data bases. This [illegible] full feature image [illegible] interfacing for numerous [illegible] One/20 systems are [illegible] due to anticipation of [illegible] memories and software.







Capability & Flexibility

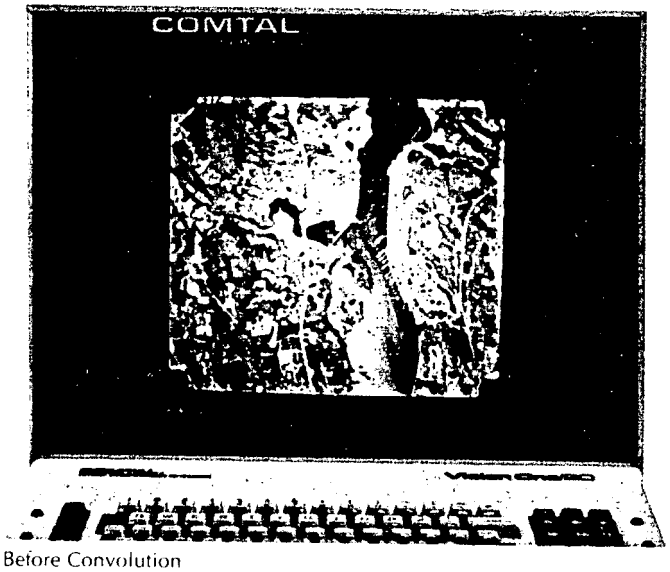
Advances in random access memories have had a significant impact on the capabilities of interactive digital image processing systems. Today, the Vision One/20 affords multiple user access to a common expandable data base (4096 x 4096 pixel memory images are available) with dynamic partitioning to allow a multiplicity of different applications. Real-time roaming (with window sizes of 512 x 512 or 1024 x 1024 pixels) through the data base is possible, with zooming and 3 x 3 convolution all implementable in 1/30th second. Refresh memory rates are 10M pixels/sec. for the 512 system and 40M pixels/sec. for the 1024 system. With graphics memories; annotation, labeling, outlining and arbitrarily shaped multiple small area monochrome or color correction are possible. Due to the dynamic allocation of the data base refresh memory, digital loop movies in real time are possible, as is left-right, right-left, up-down, and down-up scrolling of new imagery into the refresh memory and viewing window.

Pipeline Processors

Using pipeline processing to recompute all picture elements in the monochrome or true color viewing window in 1/30th second, the Vision One/20 permits partitioned or shared use of as much as 134M bits of dual ported semiconductor refresh RAM. And it uses an LSI microcomputer to handle the switching and control of high resolution pictorial images, manage memory and control the overall system in response to operator commands via keyboards, track balls or digital tablets with programmable (shape and color) targets on the monitors. Internal processing speeds allow over 70 Mega-operations per second (an operation being a multiplication and addition) for real time convolution and zooming. Freeze frame feedback allows user programmed iterations for more powerful spatial filtering as well as larger zooming. Dual porting of the memory allows image loading and display on a non-interfering basis. Although the monitor display can present only a 512 x 512 or 1024 x 1024 portion of the full image in memory, the pipelining permits roam and zoom by the operator to magnify or shrink any portion instantly, thus adequately dealing with an entire image as large as 4096 x 4096 pixels.

The Ultimate in Digital Image Processing

STAND-ALONE IMAGE EXPLOITATION SYSTEM ROAM ZOOM CONVOLVE COLORED GRAPHICS ITERATIVE FILTERING FIRMWARE OPERATING SYSTEM OVER 100-IMAGE MANIPULATION INSTRUCTION SET 512 x 512 OR 1024 x 1024 DISPLAYS MULTIPLE USER STATIONS 4096 x 4096 DYNAMICALLY ALLOCABLE DUAL PORTED REFRESH MEMORIES SMALL AREA COLOR CORRECTION LOOP MOVIES FREEZE FRAME REWRITE BRIGHTNESS COMPENSATION INTERACTIVE PAGE LAYOUT COMPOSITION



Before Convolution

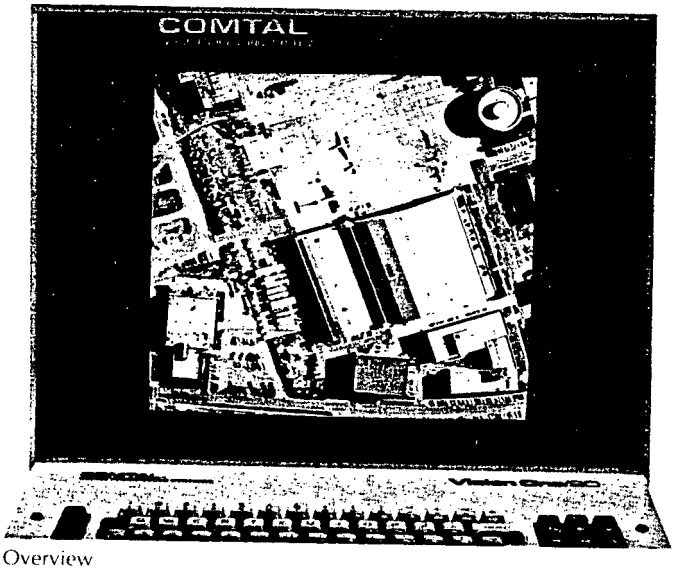
After Convolution

Firmware Operating System

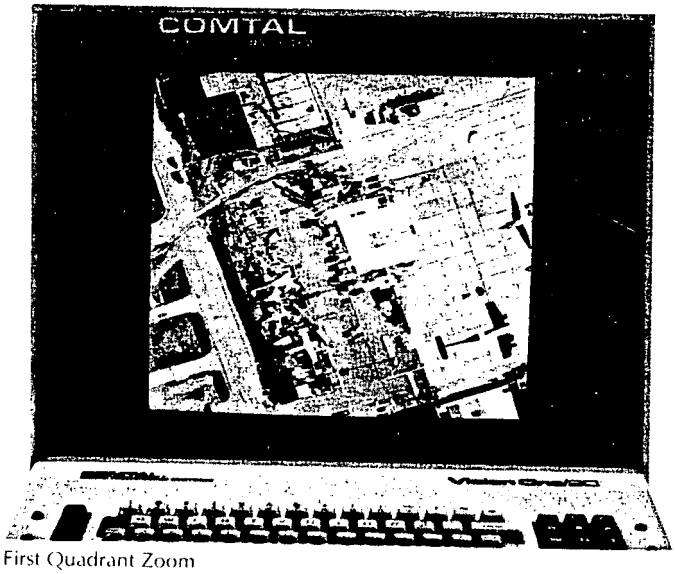
The system computer (with hardware arithmetic functions in its own right) is integral in the system with all display processing hardware instructions as part of the address space of the computer memory eliminating the normally encountered time-consuming operation of instruction I/O. The unique Comtal operating system includes over 100 high level language graphics and image manipulation instructions burned into firmware. Instruction programming, linking (MACRO's) and execution in software are all keyboard implementable. Firmware memory management by the LSI facilitates the handling of high resolution color graphic art imagery on the one hand, multiple station monochrome reconnaissance imagery on the other, and on to multi-level raster color graphics for a third application. Such memory management also lets the service engineer remove boards for repair or add blocks of memory. The system automatically senses which boards are connected on-line and makes best use of them. This dynamic allocation of memory truly makes the Vision One/20 a most versatile image processing station.

Stand Alone Instruction Set

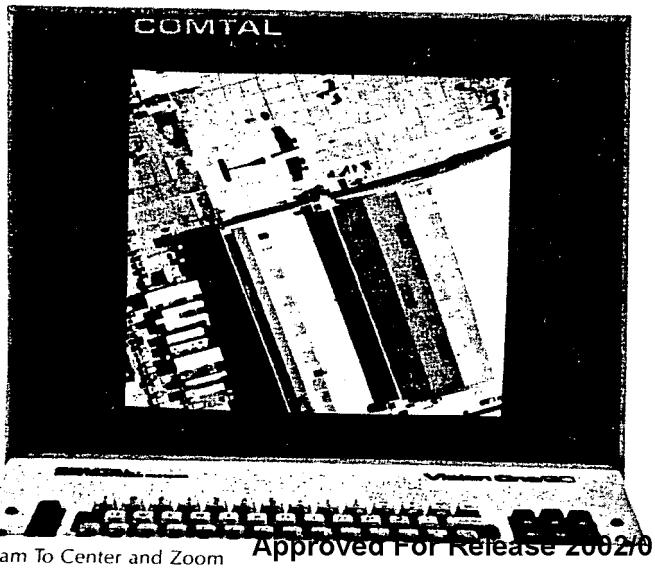
The firmware allows the user to interact with the Vision One/20 through a set of high level commands that require only initial letters from the keyboard to complete instruction definition. **Memory Management** commands permit users to define their image sizes and depth (i.e. monochrome or color), scratch images and allocate memories. **Presentation** commands allow the system to combine images for display, adding graphics for labeling, outlining, and overlay. **Pipeline Processor** commands permit brightness corrections, analytical function loading, pseudo color control and dynamic brightness correction adjustment, in addition to roaming, zooming, image arithmetic combination and convolution implementation. **Utility** commands permit keyboard programming, linking and chaining of instructions for MACRO construction and execution. **Input-Output** commands allow image transfer to and from the Vision One/20 via the many interface options including disc, magnetic tape, and host computer.



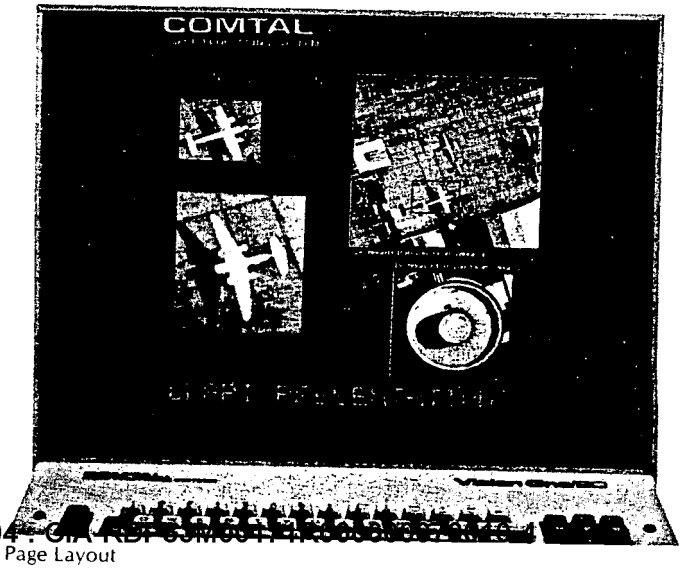
Overview



First Quadrant Zoom



Roam To Center and Zoom



Page Layout

Quality With Precision—The Key

Vision One/20 is the prime choice, with maximum versatility and powerful self-contained image processing from the system with the most to offer:

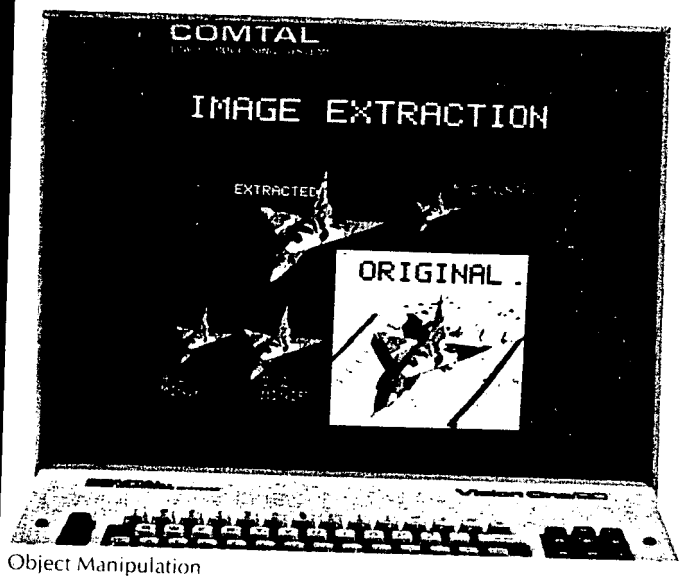
Most complete processing and versatility with high performance

Feature-filled Comtal systems have earned acclaim on a worldwide scale. Universities, aerospace companies, government agencies and foreign countries, as well as the medical community and the oil industry, all have Comtal units. From remote sensing quick-look on-line ground stations to advanced research facilities, Comtal is making breakthroughs in the analysis of 2-dimensional data possible. The scope for analysis is unlimited: *meteorological and geophysical applications through satellite pictures, criminology identification by fingerprint analysis, television or motion picture programming and automated cartooning, computer-assisted design models and non-destructive testing for quality assurance, medical imagery including ultrasound, thermography and tomography, graphic arts techniques involving composition and four-color printing are some of the main areas of challenge.*

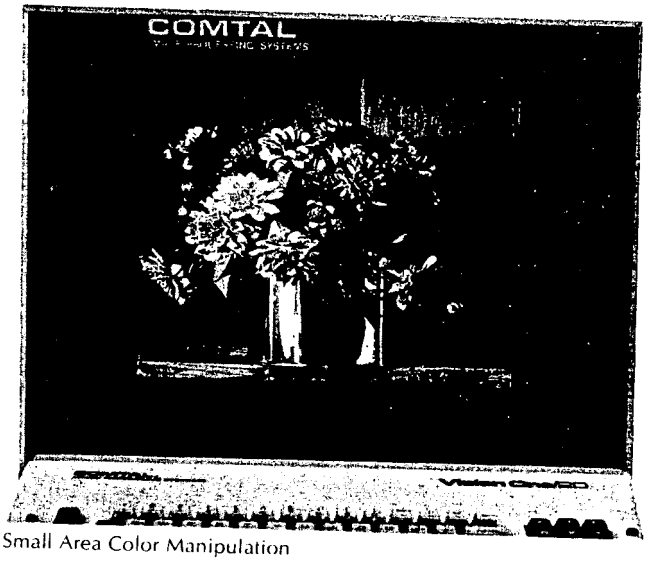
Vision One/20 image processing represents the ideal starting point for exacting visual analysis in many fields.

As for cost, the buyer knows exactly what full operational capability to expect—with or without options. Further, this also means that the very high cost of long development and time expended for support software is virtually eliminated. Practically everything required to bring data into focus for analysis is included with the competent Comtal system. Acknowledged as the most cost effective digital image processing system on the market, Vision One/20 is ready for immediate use upon delivery. Through its combination of modularity and versatility, Vision One/20 can go to work at once—and yet has the capability to be readily expanded to accommodate new applications.

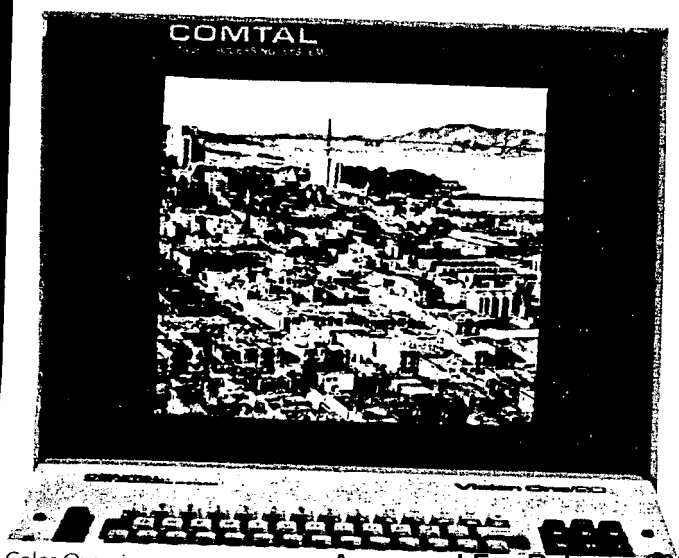
A system demonstration can be arranged to suit your convenience. Call or write—and witness at first-hand what Vision One/20 image processing can mean to your specialty. See why Comtal is the leading name in the state of the art of image processing... and Vision One/20 is the prime choice.



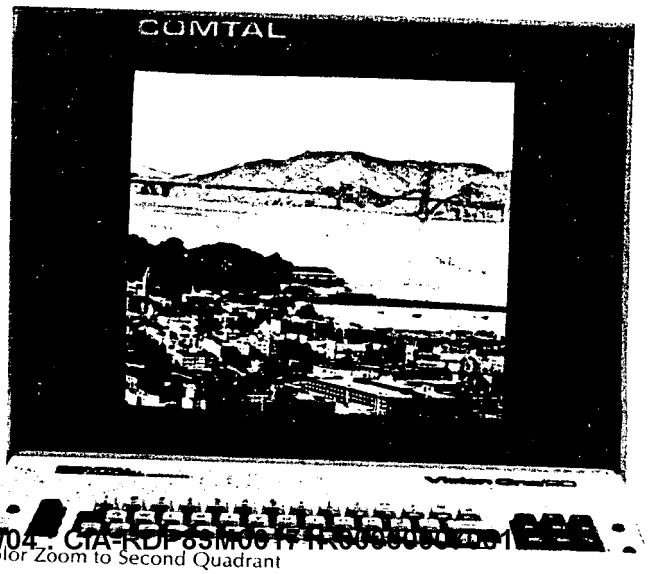
Object Manipulation



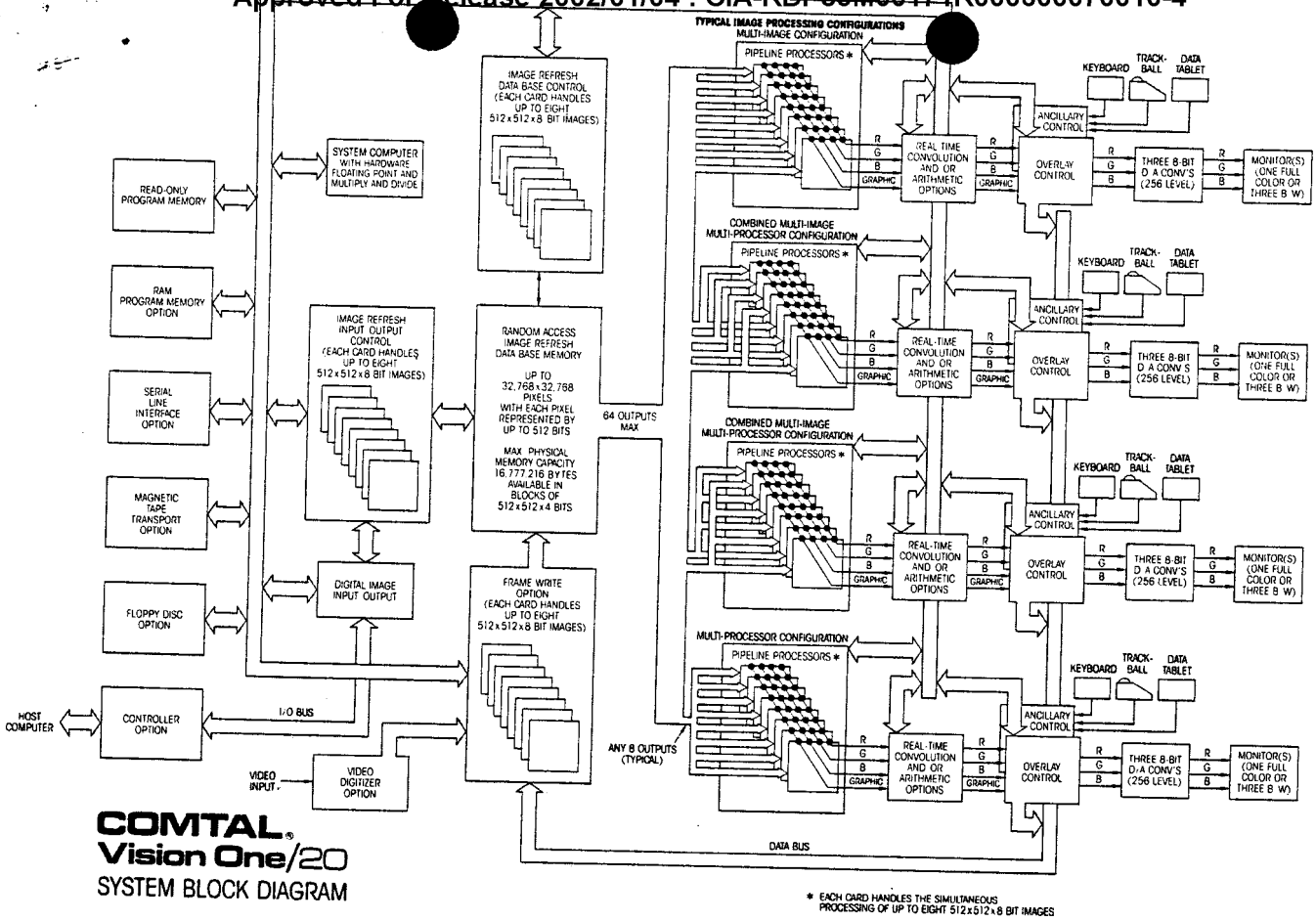
Small Area Color Manipulation



Color Overview



Color Zoom to Second Quadrant



COMTAL® Vision One/20
SYSTEM BLOCK DIAGRAM

Technical Specifications

☐ Displayed spatial resolutions of 512x512 or 1024x1024, guaranteed to meet or exceed test specifications defined in "Quantitative Evaluation of Soft Copy Displays."

- Up to 512 separate bits can represent each and every picture element in a 512x512 display presentation (128 bits per picture elements in a 1024x1024 display).
- Up to 134,000,000 bits of image refresh data base memory available in a single 6-foot electrical cabinet.
- Every one of the 134,000,000 bits of the refresh memory are read out for display in 1/60 of a second.
- Enough image refresh data base memory is available to allow a complete 4096x4096x8 bit array to be viewed in real-time.
- Any one bit of the refresh memory can be randomly addressed and read out in 800 nanoseconds.
- Dynamic assignment of image memory for either the representation of brightness increments of an image or one bit dot map overlays.
- Image refresh memory may be arrayed in spatial configurations of 512x32,768 or 32,768x512 picture elements or any other configuration in a 32,768x32,768 space.
- Refresh memory configuration assignment completely dynamic and entirely under firmware control.
- Full color, high fidelity color presentation (up to 2^{24} brightness levels image refresh and display) available in all of the spatial configurations mentioned above.
- Full 512x512 resolution real-time roam of a large data base is provided in a moving window presentation with no restrictions on the direction or rate of movement of the window presentation across the refresh memory data base.
- Zoomed presentation of any 256x256 or 128x128 picture element area of the refresh memory data base with full window capability as mentioned above.
- Loop movie presentations of up to 64 separate 512x512 spatial resolution frames, 256 separate frames at 256x256 spatial resolution and 1024 separate frames at 128x128 spatial resolution. Each frame may have up to 256 brightness levels.
- Completely independent use of the refresh memory data base by up to 4 users. Each user supplied with separate keyboard control and independent full color video output.
- Allocation of portions of the refresh memory data base dynamically assignable between users.
- Refresh memory data base data is loaded completely independent of display presentation (dual-ported construction).
- Complete random addressability to a single picture element.
- Automatic block transfer of image data provided with the ability to load sequentially from either side to either side or top to bottom or bottom to top.
- Freeze frame transfer of image data synchronously into image memory at rates of 1/30 of a second.
- Real-time rewriting of the refresh memory data base on the basis of processing algorithms in the output section of the display.
- Iterative re-processing of the refresh stored data through system contained processing algorithms performing true "pipeline" processing of the refresh stored data with each processing step taking 1/30 of a second.
- Image combining capability on the basis of plus, minus, multiply and divide.
- Real-time black and white or full color image composition — allowing the non-destructive super imposition of regular or irregular shaped portions of images one upon the other, with complete freedom of nondestructive translation of the super imposition section in any direction. The resulting composition can be [illegible] as a completely new image.

- Full independent brightness function proce[illegible] for each separate refresh stored image memory.
- Up to eight independent function processors assignable to each image. Output display presentation switchable between function processor outputs with the switching point defined by dot map memory on a pixel by pixel basis. Up to 8 independent selections may be made at each pixel location.
- Full pseudo-color processing of any section of the refresh storage data base to 2^{24} different full color values.
- Dot map graphic overlays presentable as absolute color replacement of displayed image data on a pixel by pixel basis or as the logical color "or" of assigned graphic color and the color values of the overlayed pixel.
- The display presentation of each and every graphic overlay may be colored any one of 16 uniquely identifiable colors.
- A fully digitally derived target generation system for precise pixel by pixel location definition. Entirely controlled by display system hardware with no support required from a remote computer.
- Target may be positioned by either trackball or data tablet input or both.
- Displayed target programmable to any shape that can be defined by a 15x15 array of spatial elements.
- Target may be independently colored in the same manner as graphic overlays.
- Real-time spatial convolution and image arithmetic combining feature for spatial enhancement (feature sharpening).
- Full hardware generated graphical representation of processing algorithms complete with hardware generated grid lines.
- Full image presentation—all picture elements stored are shown, none are lost in monitor retrace or display screen corners.
- A switchable time base is available which allows the alternate refresh operation of 559 line 30 frames a second and 525 line 30 frames per second. The former refresh rate allows the proper presentation of 512x512 with a minimum band width (optimizing the performance of the display monitor), the latter refresh rate allows the video recording of the information. At this rate the proper video aspect ratio of 3x4 is maintained by the insertion of black areas to either side of the image.
- Operation and annotation data block available below the display image, and non-interfering with, all the displayed image and graphic information.
- Self contained general purpose computer complete with hardware, multiply and divide and floating point arithmetic.
- Computer built into the system, not added on, for the fastest possible interaction and the shortest possible processing time. All display processing hardware is part of the address space of the computer eliminating the normally encountered time consuming operation of data input and output.

Operational Features

☐ Self-contained firmware, operable either from the local keyboard or through the systems interface, provide all commands and calculations necessary to perform the following functions without the aid of any external equipment.

- Display presentation selection.
- Image processing selection.
- Interactive real-time definition for any or all of the function processors including:
  - —Linear, or non-linear transforms defined by line segments generated from end points determined by target locations.
  - —Linear, or non-linear transforms defined by segments generated by target following. Segments are delineated by "follow-on—follow-off" technique
- Real-time histograms of any refreshed image with results automatically-scaled and plotted on a graphic overlay. Maximum and minimum brightness values are also plotted.
- Real-time histograms of any rectangular or irregular area from any refresh-stored image. Section defined by a rectangle drawn in a graphic overlay is defined by upper-left and lower-right corners provided by target locations. Shape, area, and image statistics are numerically presented.
- Non-destructive extraction of any size and shape rectangular or irregular area from any refresh stored image. The information in the resulting area may then be automatically reduced or enlarged using interpolation routines. The resulting image section may be inserted at any location in any other refresh stored image.
- Intensity profile of any i[illegible] vertical or horizontal line automatically plotted on [illegible]phic overlay.
- Pseudo-color processor content loading by step color assignment or by continuous variation of red, green and blue components. Save and restore function and pseudo-color contents.
- Function processor transform rotated either by position as defined by target location, or by rate and direction (continuous rotation) as determined by target location. The transform can also be interactively shifted with dipping at the end points.
- Pseudo-color processor memory contents rotated either by position as defined by target location, or by rate and direction (continuous rotation) as determined by target location.
- Automatic histogram equalization of function processors on the basis of the intensity distribution of the associated image.
- Fifteen user-programmable function keys which display the most often used image presentations with a single key stroke. Complete flexibility in the assignment to each key.
- Five function keys to control and select options.
- Instantaneous read and numeric display of existing target coordinates and associated picture-element intensity values.
- Modification of any given pixel value to any defined pixel value with pixel location supplied by target location.
- Automatic cosmetic image correction, changing a given pixel point, as determined by the target location, to the average value of the pixels of a 3x3 array surrounding the selected pixel.
- Complete alphanumeric text composition for insertion of any graphic overlay. Preview of copy shown below bottom edge of image display. Text insertion may start at any pixel location as defined by target location.
- Automatic line drawing on any graphic overlay. The line "follows" the target location as it moves about the screen. Control of target location may be by trackball or the more interactive data tablet. With the data tablet in use the target may be moved without drawing a line (line drawing is controlled by pressing down on the data tablet pen). Either drawing or erasing may be performed in the same manner.
- Automatic image display sequence for multi-image presentation. Sequence and rate of presentation completely flexible and interactively controlled. Image presentation may be with or without pseudo and/or function processing.
- Automatic clearing or setting of all image, graphic, function and pseudo-color memories.

☐ Magnetic Tape Handling (Option)

- Simple self-prompting user-defined magnetic tape format parameter selection.
- User-defined image loading point in both X and Y dimension.
- Tape search and positioning.
- Average and truncated overview image presentation.
- Full data write capability from all image or graphic memories, image data after processing, function memory data, pseudo-color data, user-defined function keys display-command assignments, table data, and the software memory area. Corresponding load (read) operations.
- Continuous read of blocked or blocked/unblocked image tapes in the moving window (fall or rising raster) display mode. Either single or multiple image loading.

P.O. Box 5087, Pasadena, California 91107
(213) 797-1175; TWX 910-588-3256

METROLOGIE
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ROHDE & SCHWARZ ENGINEERING AND SALES GMBH
5000 Köln 1 Postfach 10 15 44 [illegible] Germany
Telefon (Köln 0221) 77 22-1 Telex 8 885 417

ARTICLE OF INTEREST

Republicans Urge Restructuring of Intelligence Community

The Republican National Committee, following a detailed study by its special intelligence panel, has called for restructuring the US intelligence community, including creation by Congress of a Joint Committee on Intelligence. The Republican body, with obvious partisan gusto, charged that "if we were to continue to try to work with the Administration's proposed intelligence charter . . . we would in effect be accepting the initial logic of those who believe their mission to be that of 'chaining the rogue elephant' of American intelligence. By accepting their charter, we would in effect be accepting their curiously biased view that the main threats to our liberties come from our own government instead of from our external enemies."

Alleging that a wide range of deficiencies mars the Administration's proposed intelligence charter (known as the "National Intelligence Reorganization and Reform Act of 1978"), the Republican National Committee's counterproposal calls for a chief intelligence advisor to the President who would provide liaison and guidance to the intelligence community without participating in the national intelligence estimates. The intelligence advisor would also give Congress the President's views on intelligence matters and serve as the intelligence community's sole contact with the news media.

The Republican plan recommends further that the several agencies making up the intelligence community be headed by directors whose terms of office would overlap administrations to increase independence and depoliticize the intelligence process. The clandestine branches of the various intelligence agencies would be merged into a specialized "Foreign Operations Service," charged with secret intelligence gathering, covert operations, and counterintelligence abroad. This service "would be wholly clandestine; every agency of the US government would be required to furnish the [Foreign Operations Service] with full credentials, working assignments abroad for 'cover,' and full cooperation. New legislation should also provide immunity for American corporations and other entities in the private sector in connection with any lawsuits directed against them for permitting intelligence officers to use their activities as a 'cover.' Finally, the law should neither inhibit nor prohibit any American citizen from lending assistance to his country's clandestine intelligence if he so desires."

The Republican group found pervasive flaws in the way National Intelligence Estimates (NIEs) are arrived at. Asserting that "nothing has so endangered the United States" as the NIEs' chronic underestimation of the Soviet Union's strategic buildup, the Republican group characterized these misassessments as "an intelligence abuse of the first magnitude." The Republican task force called for reestablishing the President's Foreign Intelligence Advisory Board that was disbanded by the Carter Administration—or a similar permanent agency—to perform a constant "audit" of national intelligence resources and to assure that "its own opinion and counsel reach the President, his top advisors, and the Congress free of any institutional, organizational, or policy bias."

The Republican group also proposed that more than one element of the intelligence community author national intelligence estimates "in order to have constructive competition and to foster impartiality." The National Foreign Assessment Center, at the moment the only intelligence organization making intelligence estimates, should be competing against either "a much-improved Defense Intelligence Agency or a wholly new source of alternative analysis."

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